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Review

Environmental assessment schemes for non-domestic building refurbishment in the Malaysian context

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A B S T R A C T

The increase in global warming, energy consumption and greenhouse gas emissions has gained attention in various regions. In Malaysia, the government announced a voluntary commitment to reduce 40% of CO_2 emissions by 2020 and to refurbish 100 government buildings. Existing buildings make a large contribution to energy consumption and CO_2 emissions, therefore refurbishing existing buildings is an essential strategy to achieve the commitment. There is no single assessment scheme for building refurbishment in Malaysia and hence, this study aims to develop a comprehensive list of assessment themes and sub-themes for building refurbishment purposes. It examines and compares 10 assessment schemes from various countries: BREEAM, LEED, CASBEE, BEAM Plus, GBLS, Green Star, HQE, Green Mark, GBI and MyCrest. The findings revealed fourteen themes that were considered for assessment: *management*, *sustainable site*, *transport*, *indoor environmental quality* (*IEQ*), *water*, *waste*, *material*, *energy*, *pollution*, *innovation*, *economic*, *social*, *culture and quality of services*. Energy and IEQ are dominant themes in all assessment schemes. Most of the schemes are considered relatively weak in evaluating economic and social aspects, in comparison to environmental aspects. The assessment of quality of services is overlooked in most of the schemes, including GBI and MyCrest in Malaysia. Outcomes from this paper will form the baseline for a new environmental assessment scheme that aimed at non-domestic building refurbishments in Malaysia. A new model is proposed for the development of an environmental assessment scheme in the further stage.

Contents

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1. Introduction

Concern for environmental sustainability is increasing. The growing evidence of global warming and climate change requires immediate action to avoid potentially serious consequences for future generations (IPCC, 2014). Buildings have a significant impact on the environment as they use resources, generate waste and emit potentially harmful atmospheric emissions throughout their life cycle. This has resulted in buildings being one of the largest sources of CO_2 emissions and global warming worldwide (Raslanas et al., 2013). The building sector accounted for one-quarter to one-third of all energy use and a similar proportion of greenhouse gas (GHG) emissions (UNEP, 2009; WBCSD, 2009; ABC, 2007) because buildings have a long life expectancy and require continuous consumption of natural resources (energy and water) for decades after construction (Yang et al., 2013).

With rapid development and industrialisation, Malaysia is becoming heavily reliant on energy, resulting in a significant increase in GHG emission. Table 1 shows that the total energy demand increased over a period of 5 years by 37.7%, from 41,476 kt in 2010 to 57,123 kt in 2015 (EPU, 2015). The highest percentage of energy demand estimated for 2015 was by the transportation sector, at 41.2%, followed by the industrial sector at 24.3% and the residential and commercial sector at 18.1%. The average annual growth rate for the residential and commercial sector is high, at 16.4%. Begum and Pereira (2010) reported that commercial buildings alone in Malaysia account for a fifth of total domestic energy consumption. Office buildings consume about 70–300 kW h/m^2 per annum, which is 10–20 times greater than residential buildings (Yang et al., 2008). Hence, it is articulated non-domestic buildings contribute highly to energy consumption and CO_2 emissions.

Malaysia is facing a trend of increasing CO_2 emission and energy consumption per capita (Begum et al., 2015). According to the United Nations Development Programme (UNDP), Malaysia's building sector consumed approximately 7750 GW h of electricity and emitted 5301 kt of GHG in 2008 (UNDP, 2011). As shown in Fig. 1, the forecast predicts that there is an annual increase of energy consumption and CO_2 emissions in the Malaysian building sector.

In Malaysia, over 40% of GHG emissions are attributed to existing buildings and the surrounding communities (Shika et al., 2012; Boon, 2010). It is reported that GHG emission in Malaysia is expected to reach 12.1 t by 2020, compared to 10.8 t in 2011 (The Borneo Post, 2015). The Malaysian government has set a voluntary target to reduce 40% of carbon emission by 2020 (NC2, 2011). Hence, Malaysia should start playing an active role in implementing strategy and policies to achieve this target.

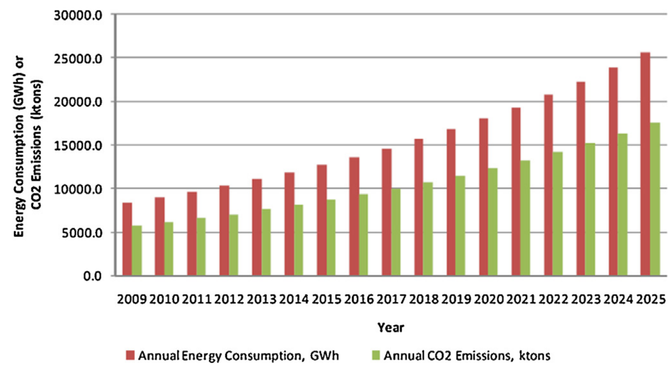

Fig. 1. Business-as-usual (BAU) forecast of annual energy consumption and CO_2 emissions for Malaysian building sector (UNDP, 2011).

The building sector has been identified as having the biggest GHG emission reduction potential (IPCC, 2007), and existing buildings, especially commercial buildings, have a crucial role to play in addressing sustainability (Shika et al., 2012). Research carried out in Malaysia predicts potential reduction in energy consumption of 15–25% in existing buildings through energy efficiency practices (Ahmed and Nayar, 2008). This can be achieved through building retrofit, by improving the building's envelope using suitable insulation material to minimise heat loss. Other energy-efficient practices include efficient electrical equipment to reduce electricity consumption, as existing buildings contain much old equipment. As a result, building refurbishment offers a significant opportunity to make the existing building stock more suitable for the carbon future. As pointed out by Shika et al. (2012), refurbishing existing buildings presents the largest potential to reduce energy demands and GHG emissions. In the Eleventh Malaysia Plan (2016–2020), the Government has initiated refurbishing measures to existing

Table 1
Energy demand by sector, 2010–2015.

Sector	Kilo tonnes of oil equivalent (ktoe)			% of total			Average annual growth rate (%)
	2010	2013	2015[a]	2010	2013	2015[a]	2011–2015
Transportation	16,828	22,522	23,535	40.6	42.3	41.2	6.9
Industrial (manufacturing, construction and mining)	12,928	13,384	13,367	31.2	25.1	24.3	0.7
Residential and commercial	6951	7378	10,339	16.8	13.9	18.1	16.4
Non-energy (natural gas, bitumen, asphalt, lubricants)	3696	9111	8968	8.9	17.1	15.7	19.4
Agriculture and forestry	1074	827	914	2.6	1.6	1.6	−3.2
Total	41,476	53,222	57,123	100	100	100	6.6

Source: EPU (2015).
[a] Estimate.

Table 2
Summary of 10 building assessment schemes.

Schemes	Country	Year first published	Developer	Assessment scheme	References
Building Research Establishment Environmental Assessment Methodology (BREEAM)	UK	1990	Building Research Establishment	BREEAM UK Refurbishment and Fit-out 2014	BREEAM (2015a)
Leadership in Energy and Environmental Design (LEED)	USA	1998	US Green Building Council, CNU (Congress for the new urbanism), NRDC	New construction and major renovations (v4)	USGBC (2011)
Comprehensive Assessment System for Built Environment Efficiency (CASBEE)	Japan	2001	Japan Sustainable Building Consortium, Japan Green Building Council	CASBEE-renovation	CASBEE (2015)
Building Environmental Assessment Method (BEAM) Plus	Hong Kong	1996	Hong Kong Green Building Council	New Building Version 1.2	HKGBC (2012)
Green Building Labelling System (GBLS)	Taiwan	1999	Taiwan Architecture and Building Research Institute	GBLS: EEWH-renovation	GBL (2013)
Haute Qualité Environnementale (HQE)	France	1996	HQE Association	Environmental performance non-residential buildings	HQE (2013)
Green Star	Australia	2003	Green Building Council of Australia	Design and As Built	GBCA (2014)
Green Mark	Singapore	2005	Building and Construction Authority	Non-residential existing building	BCA (2012)
Green Building Index (GBI)	Malaysia	2010	Malaysian Institute of Architects and the Association of Consulting Engineers Malaysia	Non-residential existing building	GBI (2011)
Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCrest)	Malaysia	2013	Public Work Department Malaysia and Construction Industry Development Board	New Construction	CIDB (2013)

buildings and there is a target to retrofit 100 government buildings. In order to achieve this, an assessment scheme for building refurbishment is essential.

The Malaysian construction industry has been developing and working towards more sustainable ways. The Green Building Index (GBI) was developed in 2009 (CSI, 2013) and MyCrest (CIDB, 2013) was established in 2013 to promote sustainability in the built environment and raise awareness among industry players. Nevertheless, it only contains new and existing building assessment schemes. There is still no single scheme for refurbishment purposes in the Malaysian construction industry. Therefore, this paper aims to critically examine and compare existing schemes from various countries in order to identify suitable assessment themes and sub-themes for refurbishment purposes. A review of assessment themes is indispensable as assessment schemes evolve rapidly, requiring in-depth study of the recent schemes from various regions. Compiling a comprehensive list of assessment themes and sub-themes provides an overview of the latest assessment trends and best practice. This knowledge sharing will be useful for the government, assessors and scheme developers, and can be used for future practice by other countries who would like to develop their own assessment schemes. It depicts a clearer understanding of the needs and requirements that are going to be applied for sustainability assessment.

2. Review of building environmental assessment schemes

This study seeks to investigate important and prevalent environmental assessment schemes from different countries. This in turn establishes the essential sustainable themes for potential consolidation into new schemes for refurbishing buildings in Malaysia. Many countries have either developed or are in the process of developing their own assessment schemes. Each region has its own geographical and cultural characteristics, and many schemes have been developed for specific sites and local purposes.

This study examines 10 assessment schemes selected from both developing and developed countries: UK, US, Japan, Hong Kong, Taiwan, France, Australia, Singapore and Malaysia. The selection was based on several themes such as the prominence of the assessment schemes, most frequent appearance in the literature, and ease of access to the assessment manuals. Table 2 tabulates the 10 assessment schemes reviewed in this study. These assessment tools from different countries are analysed and compared in order to identify the similarities, differences, strengths and weaknesses in terms of general characteristics, weighting, scoring and assessment themes with sub-themes. In turn they highlight the areas for improved assessment and inclusion in the revised refurbishment assessment scheme for Malaysia. This study therefore adopted a comparative methodology to draw up a list of the common assessment themes and sub-themes from 10 widely adopted schemes. These comparative studies designed to identify the themes for assessment among various assessment tools is widely adopted from previous studies (Lee, 2013; Michael et al., 2014; Sharifi and Murayama, 2013, 2015; Ameen et al., 2015).

The study conducted a comprehensive literature review of each assessment tools evaluated and a preliminary list of assessment themes and sub-themes was compiled from various relevant publications (Alyami and Rezgui, 2012; Lee, 2013; Ding, 2008; Haapio and Viitaniemi, 2008; CSI, 2013; Michael et al., 2014; Tanguay et al., 2010). This list was compared against individual assessment tools to complement them and ensure that all related assessment themes and sub-themes were included. Summative content analysis (Hsieh and Shannon, 2005) of the literature, such as the manuals of 10 assessment schemes, was the main methodology adopted for analysing the assessment themes and sub-themes to update and consolidate the preliminary list.

It is found that majority of the schemes were dedicated to new buildings. Of the 10 schemes examined, BREEAM, CASBEE and GBLS have a dedicated assessment version for building refurbishment. Few individual assessment schemes are dedicated to refurbishment, and the majority use either new or existing building versions for refurbishment. It is noteworthy that some of the assessment schemes are not only applied to building assessment, but also to urban neighbourhood assessment (BREEAM, LEED, CASBEE, Green Star, GBLS, HQE and GBI).

BREEAM was developed by the Building Research Establishment Limited (BRE Ltd.) to evaluate the performance of new and existing buildings. BREEAM also has a separate scheme for refurbishment and fit-out for buildings developed in 2015 (BREEAM, 2015a). Globally, almost 2.2 million registered buildings and over 500,000 buildings have been certified via BREEAM (BREEAM, 2015b). BREEAM assessments have been used as a template and reference model for the creation of assessment schemes in Canada, New Zealand, Hong Kong, China, Norway and Singapore (Ding, 2008; Lee, 2013).

LEED, developed by the US Green Building Council (USGBC) applies to new and major renovation projects (LEED-BD + C), existing buildings (LEED-O + M), interior projects (LEED-ID + C), homes (LEED-homes), and neighbourhood development (LEED-ND). The LEED assessment has been used in 41 countries, including Canada, Brazil, Mexico, India and China (Lee, 2013). Hence, BREEAM and LEED are the leading schemes and have a proven record in the domain of sustainability development. Both are widely recognised and have been successfully exported to many other regions (Lee, 2013). Other developed countries like Japan and Hong Kong have also developed their own schemes, respectively CASBEE and BEAM Plus, that have significant effects on their building industries. CASBEE is considered noteworthy (Howard, 2005) whilst BEAM Plus is the most widely used voluntary scheme (Chan, 2005).

The CASBEE scheme was developed by the Japan Green Building Council (JaGBC)/Japan Sustainable Building Consortium (JSBC) and their sub-committees (Lee, 2013). CASBEE is applied to pre-design, new construction, existing building and renovation, corresponding to the building life cycle. Similar to BREEAM, CASBEE includes a scheme for refurbishing existing buildings to produce more environmentally efficient building stock.

BEAM Plus is a voluntary scheme first launched in 1996 (formerly known as HK-BEAM). It was based largely on the BREEAM assessment scheme but was modified for Hong Kong's densely populated infrastructure. It applies to new and existing buildings and covers a wide range of issues related to the impact of buildings on the environment in terms of global, local and indoor scales (Lee, 2013).

In Taiwan, GBLS (also known as EEWH: ecology, energy saving, waste reduction and health) was developed based on the country's subtropical climate, with high temperature and humidity. It consists of five individual schemes, including basic for general green building practices, residential building, factory, and renovation for existing buildings and community (CSI, 2013). By the end of December 2013, GBLS had certified a total of 4300 buildings as green buildings.

The Green Star assessment scheme was developed in 2003 by a non-government organisation, the Green Building Council of Australia (GBCA). It is a comprehensive, national, voluntary environmental assessment scheme and has been adopted by other regions; for instance, Green Star New Zealand and Green Star South Africa were developed by the New Zealand Green Building Council and Green Building Council of South Africa.

HQE was developed by the non-governmental organisation HQE based in Paris, France. It originated in 1996 at the initiative of the French Ministry of Equipment to set environmental and health criteria for buildings (CSI, 2013). This scheme applies to new buildings, existing buildings and urban development, with defined performance criteria which are then implemented through a series of management requirements.

In Singapore, Green Mark was introduced by the Building and Construction Authority (BCA) in 2005. It aims to evaluate buildings for environmental impact and performance, and promote sustainable design, construction and operational practices throughout the City–State Republic of Singapore (CSI, 2013). It can be applied to new buildings, existing building, office interiors, landed houses, infrastructure and districts.

In 2010, the Malaysian Institute of Architects (PAM) and the Association of Consulting Engineers Malaysia (ACEM) developed GBI. It is derived from Singapore's Green Mark and the Australian Green Star, but developed within the context, cultural and social needs of Malaysia's tropical climate, environment and development (CSI, 2013). GBI is applicable to new and existing residential and commercial buildings in Malaysia.

On the other hand, the Public Work Department (PWD) Malaysia and Construction Industry Development Board (CIDB) have recently developed MyCrest to guide industry players in designing, constructing and operating buildings that integrate low carbon and sustainable practices. It was developed by taking into account the whole building life cycle beginning from pre-design until the demolition stage. Compared to GBI, it aims to integrate socio-economic considerations into the built environment.

3. Findings

Environmental assessment schemes share broad themes. Common assessment themes can be divided into: management, sustainable site, transport, indoor environmental quality (IEQ), water, waste, material, energy, pollution, innovation, economic, social, cultural and quality of service.

In terms of a weighting system, most of the assessment schemes allocated a certain number of points to be fulfilled. Hence, for better comparison, normalisation of scores was carried out to adjust the values measured on different total scores to a 100% point to ensure consistency. The weighting for each assessment scheme, after conversion to the 100% point for comparison, is displayed in Table 3.

Most of the assessment schemes allocated higher scores to the theme energy, followed by IEQ. The contribution of buildings towards energy consumption steadily increased by between 20% and 40% in developed countries (Saidur, 2009). With growing populations and more time spent inside the buildings, it is predictable that there will be an upward trend in energy demand in the future. This is no doubt why most of the assessment schemes assigned more weight to energy, with the prime objective being energy reduction.

On the other hand, CASBEE and HQE emphasised IEQ first, followed by energy. HQE evaluated IEQ comprehensively by several aspects such as thermal comfort, acoustic comfort, visual comfort and olfactory comfort (HQE, 2013; CSI, 2013). CASBEE also evaluated IEQ broadly, by sound, temperature, lighting and air quality (CASBEE, 2015). Both schemes assigned more points to IEQ than did other schemes. This is due to increasing concern about sick house syndrome (SHS) in Japan (Nakayama and Morimoto, 2009) and in France (Rivière and Lafitte, 2013). In Japan, poor ventilation in a room has caused serious health problems such as SHS (Hobday, 2011). Therefore, IEQ is rapidly becoming a key concern in achieving sustainability, as building occupants will spend most of their time inside the building. Hence, better IEQ can enhance the health of building occupants by reducing SHS.

The detailed results, with sub-themes, are given in Appendix A. Each theme is discussed in the following sub-section.

3.1. Management

This theme deals with how buildings can be adequately operated and maintained throughout the building life cycle (Alyami and Rezgui, 2012) from project brief, design, construction, commission, and handover. It is to ensure that sustainability objectives are set at the beginning of the project and followed through into the building operation. Appendix A shows that BREEAM, GBI and MyCrest have established comprehensive sustainable management practice

Table 3
Weighting for building assessment schemes.

Themes	WEIGHTING (%)									
	BREEAM	LEED	CASBEE	BEAM Plus	GBLS	HQE	Green Star	Green Mark	GBI	MyCrest
Management	8	6	4	6		1	8	3	10	9
Sustainable site	9	6	4	5	17	2	4.5			6
Transport	7	12	5	4		3	9	2	2	3
Indoor environmental quality	13	14	**22**	19	10.5	**45**	16	19	24	10
Water	6	13	4	7	12	11	12	13	12	7
Waste	5	2	1	3	10	3	2	4	3	4
Material	10	8	12	12	8.5	2	12	5	6	9
Energy	**17**	**24**	17	**24**	**28**	22	**20**	**41**	**26**	**39**
Pollution	9	4	11	10	12	8	4.5	7	4	5
Innovation	10	5		4			10	6	10	5
Economic	2									0.5
Social		4	2	2						0.5
Cultural		2	5	1						1
Quality of service	4		13	3	2	3	2		3	1
TOTAL SCORE	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Remarks:
– Highest score.
– Second-highest score.

from project brief to maintenance stage, whereas other schemes can be considered relatively weak in this aspect. The management of project brief, design, construction activities, commissioning and maintenance is crucial to ensure the project lifecycle fulfils the sustainability goals.

3.2. Sustainable site

This is generally divided into two aspects: construction site and ecological value. Site location and protection should avoid development of inappropriate sites, whereas the latter aspect is to encourage habitat protection and improve biodiversity. From Appendix A, it is noticeable that BREEAM, CASBEE and GBLS, which have individual refurbishment schemes, do not evaluate the aspect of construction site but emphasise a site's ecological value. Hence, the ecological aspect is more important in refurbishment assessment than in construction sites. This is to encourage protection and develop existing ecological features suffering from substantial negative damage from construction development. Hence, the majority of schemes evaluate the ecological aspect as important.

3.3. Transport

In order to reduce congestion and air pollution due to private vehicles, better access to sustainable means of transport is encouraged in most of the assessment schemes except GBLS. The aim of this theme is to deliver a good level of communication, through easy access to public facilities and services and adequate provision for pedestrians, cyclists and drivers (BRE, 2011; USGBC, 2011).

Appendix A shows that public transport accessibility and car parking capacity are considered in most of the assessment schemes. These two sub-themes are interrelated as reducing car parking capacity encourages the building's users to use public transport. Adequacy of local amenities and public transport at site location are crucial in reducing travel needs and reliance on private vehicles. Hence, a travel plan is essential in assessing travel patterns and transport impact. However, not many assessment schemes emphasise the need for a travel assessment plan for buildings.

3.4. Indoor environmental quality (IEQ)

IEQ is a popular theme in all assessment schemes, according to Alyami and Rezgui (2012) in order to increase the comfort, health and safety of a building's occupants. The most popular sub-themes considered in most of the assessment schemes are noise and acoustics, lighting and illumination, thermal comfort, ventilation and contamination level; odour is least considered in most of the schemes. Appendix A shows that BREEAM, LEED, CASBEE, BEAM Plus and HQE cover all these themes to some extent.

The assessment of noise and acoustics is to ensure the building's acoustic performance meets the appropriate standards and design ranges in term of noise level, sound insulation, and absorption and background noise. However, MyCrest does not include this assessment theme. Daylight penetration into a building is essential to ensure visual comfort and performance for a building's occupants. It can be achieved by providing good daylight and sufficient illumination levels, controlling glare through the form of the building, providing adequate views out to reduce eyestrain, allowing occupants to control lighting, and using efficient lighting fittings to reduce electricity consumption.

Appropriate and uncontaminated ventilation is crucial for healthy indoor air quality (IAQ). The IAQ plan refers to pre-occupancy flushing out to remove contaminant sources. An adequate level of fresh air can be provided through natural ventilation or mechanical ventilation systems, through air purification to allow incoming fresh air to be correctly diffused throughout all of the rooms and away from pollution sources. For building areas that have large occupancy patterns, CO_2 monitoring is important by installing CO_2 sensors. Apart from ventilation, appropriate thermal comfort can be achieved through design and control.

Indoor contamination levels such as volatile organic compounds (VOC), formaldehyde, smoke, mould, electromagnetic and biological pollutants are considered in the majority of assessment schemes, to limit the sources and effects of indoor air pollutants. Only BEAM Plus and HQE evaluated odour to ensure an appropriate level.

3.5. Water

Water is considered a limited and valuable resource, thus all of the assessment schemes included water efficiency and recycling to seek for sustainable water use and management. The aim is to minimise fresh water consumption by measuring the level of water-consuming components such as water closets (WC), showers and baths. In order to reduce demand on consumption, water recycling methods such as rainwater harvesting, grey water recycling and efficient irrigation systems are strongly encouraged in most of the assessment schemes.

3.6. Waste

Waste is covered comprehensively in all assessment schemes to ensure best practice in the management of construction and operational waste. A waste management plan is essential during construction in order to schedule in advance how the waste will be collected and sorted on the construction site. Different waste requires different treatment, such as recycling, disposal or landfill. Appropriate waste treatment will encourage reuse or recycling of the material to optimise efficiency. Dedicated space for waste storage will facilitate waste collection, with waste facilities such as recycling bins for collecting different type of waste to ease recycling. It is noticeable that all of the assessment schemes comprehensively cover the waste aspect due to its hazardous impact on human health and environmental pollution.

3.7. Material

Building materials are one of the important themes considered in the majority of assessment schemes, due to their complicated life cycle from extracting raw materials until the disposal stage (Alyami and Rezgui, 2012). Generally, this aspect can be divided into material selection, material disclosure information, efficient use of material and use of green products. Particular emphasis is placed on material selection.

In terms of material selection, BEAM Plus and MyCrest cover most of the sub-themes, although selection of materials with a low environmental impact is considered in the majority of assessment schemes. The purpose is to be aware of the impact of the material by taking account its life cycle assessment (LCA). Most of these schemes encourage use of a LCA tool such as building information modelling (BIM) to measure the environmental impact of the material over the building's life cycle. Responsible sourcing of materials is emphasised in most of the assessment schemes. This generally refers to timber or timber-based products to ensure they are legally harvested and from sustainable sources.

Prefabrication is considered in both Malaysian schemes (GBI and MyCrest) to reduce the waste of materials and the quantity of on-site waste. The Malaysian government encourages the use of IBS in the construction industry. Use of green products such as environmentally friendly refrigerants and clean agents are also encouraged, but not many assessment schemes included this sub-theme.

3.8. Energy

Assessment schemes place vital importance on the energy theme, due to its significant impact on environment. With the increasing concerns about global warming and the greenhouse effect, energy assessment is concerned with the energy performance of major building systems, efficient operation and strategy, energy management and use of natural resources.

CASBEE and HQE are considered strong in assessing energy performance and management overall, compared to other assessment schemes, although energy consumption is an issue in most countries. Most of the assessment schemes encourage the assessment of energy performance for the HVAC system, refrigeration, lift, external lighting, car park, roof and building envelope, to determine how much potential energy improvement could be achieved. Other energy saving methods, CO_2 mitigation strategies and renewable energy technologies play an important role in the assessment schemes, seeking more sustainable ways of using energy.

3.9. Pollution

This theme deals with outdoor sources of air pollution, in order to reduce it and make adequate provision to limit its effect. Sustainable construction emphasises the protection of the surrounding environment in order to minimise the effect of the construction activities on the surroundings.

The impact of refrigeration, night light pollution, heat island effect and construction activity pollution are broadly considered in most of the assessment schemes, due to their adverse effects on the surrounding environment. CASBEE, BEAM Plus and HQE deal broadly with sources of pollution. It is noted that CASBEE evaluates wind pollution and earthquake resistance within the local conditions of Japan.

3.10. Innovation

Most of the assessment schemes support innovation in the evaluation framework, as it can provide environmental benefits. Any new methods that can be shown to improve sustainability performance of a building are strongly encouraged, and BREEAM, LEED, BEAM Plus and MyCrest established supplementary themes to reflect exceptional performance (Alyami and Rezgui, 2012).

3.11. Economic aspects

The economic aspect embraces growth, development and productivity. Developed countries are concerned with social and economic aspects rather than environmental aspects (Libovich, 2005). However, neither BREEAM nor LEED includes consideration of social and economic aspects. Most schemes lack evaluation of financial aspects, which is contrary to the ultimate principle of sustainable development as a financial return (Raslanas et al., 2013). Raslanas et al. (2013) suggest that financial and environmental aspects should be considered together, especially during the financial feasibility stage while evaluating alternative development options.

3.12. Social

The social aspect deals with human wellbeing and welfare. It refers to how to attend to human needs, increasing the opportunities of development equally for all people (Michael et al., 2014). CASBEE and BEAM Plus cover more of the social themes than do other schemes. Social sustainability is essential in taking of care of welfare (privacy, security, amenities), equitably distributed among social classes and gender. Handicapped accessibility should not be neglected in the assessment scheme. When designing buildings, the wellbeing of a disabled person should be catered for, to enhance their social integration. Public open spaces such as refreshment spaces or outdoor terraces can be provided for the use of buildings' occupants. Other building amenities include kiosks, meeting rooms and recreational facilities to enhance the functionality of a building.

3.13. Culture

The cultural aspect is neglected in most of the assessment schemes except CASBEE. Building development should integrate local cultural values to enhance and promote them in design. Cultural heritage provides a means of knowing and interpreting social, cultural and economic changes. Integrating cultural aspects in the design can create a sense of belonging to the country and fostering community spirit. Therefore, preservation of cultural heritage seems important.

3.14. Quality of services

Assessment of service functions is crucial to keep a building in good condition over the long term. CASBEE evaluates comprehensively the quality of service, but this is partly neglected in other schemes. BREEAM and BEAM Plus evaluate the importance of building safety and security; for example, security equipment such as burglar alarms and CCTV can be provided. CASBEE assesses the efficiency of the floor area allocated for the required functions. Provision of appropriate space is essential to ensure the occupants can carry out their daily duties. Many assessment schemes consider the aspect of flexibility and adaptability to encourage consideration of measures to accommodate future changes to the use of the building and its systems. These may be due to change of ownership, or future expansion and growth, which require modifications to the existing building layout. Hence, consideration of design aspects, such as easy relocation of partition walls, should avoid damage to the existing ceiling and flooring. Maintenance of performance is also important to ensure that maintenance of the building itself can be carried out through good access conditions, to prolong the building's life cycle. BREEAM and CASBEE include assessment of the durability and reliability of building structures and systems to minimise the frequency of replacement.

4. Discussion

Sustainability themes and sub-themes vary from scheme to scheme, country to country, with different geographical conditions resulting in different approaches and priorities. Thus, there are different interpretations for the themes and sub-themes. The majority of the schemes emphasise environmental aspects over economic, social and cultural aspects. BREEAM and LEED, generally the most popular assessment schemes, do not cover economic, social and cultural aspects in the building environmental assessment schemes. However, they are evaluated under neighbourhood sustainability assessment tools (Sharifi and Murayama, 2014, 2015; Reith and Orova, 2015). Raslanas et al. (2013) confirm that most building assessment schemes do not satisfactorily cover social and economic aspects. This is because most countries are still facing barriers in designing their own rating methods for evaluating economic, social and cultural aspects. Banani et al. (2013) explained that the local context determines the importance of the environmental, economic, social and cultural aspects as a result of geographic and cultural variation. For instance, environmental aspects are more important in certain countries than are social and economic aspects. Thus, most countries tend to pay more attention to environmental aspects than to economic, social and cultural aspects to achieve a healthy environment.

Haapio and Viitaniemi (2008) stressed that sustainable building should include economic and social aspects in addition to the environmental aspect. Other scholars (Tanguay et al., 2010; Ibrahim et al., 2015; Michael et al., 2014) have pointed out that environmental, social and economic aspects are the main pillars of sustainable development. These sustainability pillars ensure that a country achieves economic growth and at the same time maintains a healthy balance between the ecosystem and social wellbeing. Thus, integration of these sustainable features into the assessment scheme is crucial. However, this leads to several challenges: the need to balance and also to capture the interrelationship between environmental, economic and social dimensions. Michael et al. (2014) explained that the recognition of the interweaving of these three dimensions demands greater clarity and understanding. Thus, it is necessary to equalise their importance and integrate these three dimensions, as sustainability cannot be assessed in isolation from social and economic aspects.

No single initiative tackles all these sustainable dimensions and there is no consensus around what and how should be assessed, especially the social and economic aspects (Delai and Takahashi, 2011), which make it difficult for scheme developers and policy makers. Lacking methodology and guidelines on targeting the integration of these three aspects into sustainability development is hindering major nations, especially developing countries. Jovanovic (2008) suggested that these three dimensions might be achieved by acting at the local level. This leads to a path considering the importance of these three aspects and a methodology on how to equalise them in developing the further stages of a Malaysian refurbishment scheme.

Refurbishment practice is becoming important in Malaysia as many of the existing buildings are not sustainably built. Hence, the Malaysian government has begun to promote refurbishment practices (Eleventh Malaysia Plan, 2016–2020). However, Malaysia still lacks refurbishment schemes that reflect and prioritise certain environmental, social, economic and quality of service aspects. Existing building assessment schemes in Malaysia (GBI and MyCrest) do not focus specifically on refurbishment practices, as compared to BREEAM and CASBEE. GBI does not integrate social, cultural and economic themes, and MyCrest can be considered relatively weak in assigning scores to these aspects. There is an absence of strategy in integrating these aspects that suit the Malaysian context. As the Malaysian government has a target to retrofit 100 government buildings, it is essential to provide a solution to ease the refurbishment practice. Malaysia needs to develop refurbishment schemes that will provide a yardstick for evaluation to achieve sustainable development.

Furthermore, the importance of quality of service is overlooked in GBI and MyCrest, especially the sub-themes of safety and security. Refurbishment is often carried out in limited and confined available spaces. Difficulty of access to refurbishment sites and unforeseen site conditions have increased the level of uncertainty, possibly adding risks to the building's occupants and surrounding environment. As a result, assessment of safety and security is crucial to refurbishment practices in order to protect the neighbouring occupants and surrounding environment. Hence, these are the critical assessment themes that need to be considered and consolidated in Malaysian refurbishment schemes. As mentioned earlier, given this lack of a methodology integrating the sustainability pillars, a model is proposed to depict the development stages of a Malaysian environmental assessment scheme for building refurbishment that will equalise the environmental, social, cultural and economic aspects. The model is structured into six sequential processes, as shown in Fig. 2.

There are several important stages in the development of a new assessment scheme. The first stage is the comprehensive review and comparison of the most prominent and latest environmental

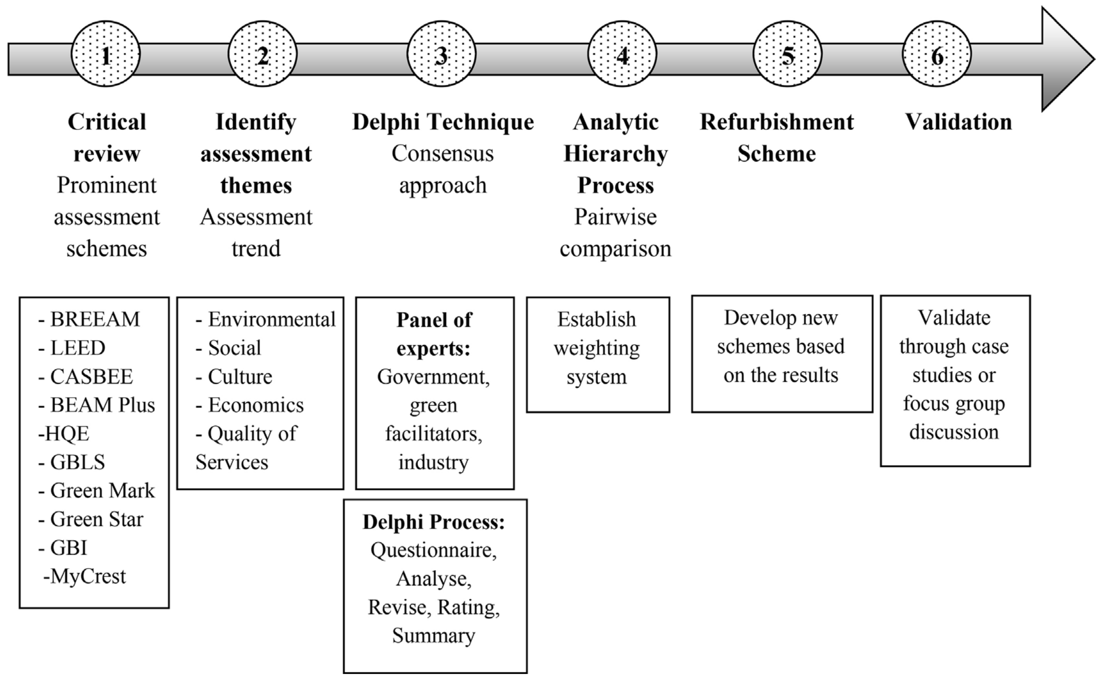

Fig. 2. Model for developing environmental assessment scheme for building refurbishment in Malaysia.
Adapted and modified from Alyami and Rezgui (2012).

assessment schemes to identify similarities and differences. This is the starting point for identifying the themes and sub-themes to define the assessment trend (second stage). In the third stage, it is crucial to select the assessment themes applicable to the Malaysian context and refurbishment practice. Previous studies confirmed that the Delphi technique is the most applicable method to develop comprehensive and effective building environmental assessment themes (Chew and Das, 2008; Alyami and Rezgui, 2012). The Delphi technique uses two to three systems, appointing experts from the field based to examine questionnaire results in order to reach consensus on the most applicable themes. In order to develop a weighting system that reflects local needs, analytical hierarchy process (AHP) is viewed as suitable method (Alyami and Rezgui, 2012). Fifthly, a new environmental assessment scheme for building refurbishment is developed, which should be subject to a rigorous testing stage for validation and adaptability. This model (Fig. 2) serves as a guideline and reference point for other countries' scheme developers, policy makers and researchers, for developing environmental assessment schemes in the local context.

5. Conclusion and way forward

Sustainability has attained worldwide attention due to increasing global warming, energy consumption and GHG emission. Various schemes have been developed and adopted by different countries with the aim of attaining sustainability for buildings. This study investigated 10 international assessment schemes: BREEAM, LEED, CASBEE, BEAM Plus, GBLS, Green Star, HQE, Green Mark, GBI and MyCrest. Different schemes highlighted different themes and sub-themes, which were used to produce a list of themes and sub-themes for Malaysia. Fourteen themes are considered by these 10 assessment schemes: *management*, *sustainable site*, *transport*, *indoor environmental quality*, *water*, *waste*, *material*, *energy*, *pollution*, *innovation*, *economic*, *social*, *culture and quality of services*. These themes are considered and consolidated into a new Malaysian refurbishment scheme.

Each country has attempted to integrate all the sustainability dimensions: environmental, economic and social. The majority of the building environmental assessment schemes emphasised the environmental aspect and partly neglected economic, social and cultural aspects. Sustainability building assessments cannot be examined in isolation from social, economic and cultural aspects. However, there are several challenges, such as equalisation among these aspects, where each should be equal to the environmental aspect. There is no initiative, strategy or mechanism to tackle all sustainability aspects. Hence, this study proposes a model as a guide for developing an environmental assessment method for building refurbishment in Malaysia after identifying the assessment themes and sub-themes.

This study is an initial step towards the development of an environment assessment scheme for building refurbishment in Malaysia. The next phase of the research will be conducting a comprehensive evaluation to identify the applicable themes and sub-themes for building refurbishment in Malaysia using the Delphi technique, in addition to enabling the development of a weighting system that reflects regional variations in the Malaysian environment by adopting AHP.

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Appendix A.

Sub-themes comparison for 10 assessment schemes.

Themes and sub-themes	BREEAM	LEED	CASBEE	BEAM Plus	GBLS	HQE	Green Star	Green Mark	GBI	MyCrest
Management										
Project brief and design	√	√								√
Construction	√			√		√	√			√
Commissioning and handover	√	√	√	√		√	√			√
Aftercare and maintenance	√		√	√		√	√	√		√
Sustainable site										
(*a*) *Construction site*										
Site selection		√		√		√				√
Site protection		√				√				√
(*b*) *Ecological value*										
Contaminated land		√		√			√			√
Mitigate ecological impact		√	√	√	√	√				√
Protect and enhance ecological value	√	√	√		√	√	√			√
Biodiversity protection	√	√	√	√	√	√				
Transport										
Public transport accessibility	√	√		√		√	√	√		√
Proximity to amenity	√	√		√			√			√
Pedestrian safety and access	√		√					√		√
Cyclist facilities	√	√	√			√		√		√
Car parking capacity	√	√	√	√		√	√		√	
Green vehicle	√	√		√		√	√	√	√	√
Travel plan	√					√	√			
Indoor environmental quality										
(*a*) *Noise and acoustics*										
Noise level	√	√	√	√	√	√	√	√	√	
Sound insulation	√	√	√	√		√	√			
Sound absorption	√	√	√	√		√	√			
Background noise		√		√		√				
(*b*) *Lighting and illumination*										
Daylight provision	√	√	√	√	√	√	√	√	√	√
Glare control	√	√	√	√		√			√	√
Illumination level	√	√	√	√	√	√	√		√	√
View out	√	√	√			√	√		√	√
Lighting zoning and control	√	√	√	√		√	√	√	√	√
Lighting efficient fittings	√							√	√	√
(*c*) *Thermal comfort*										
Thermal design and modelling	√	√	√	√		√	√	√		√
Thermal zoning and control	√	√	√			√		√		√
(*d*) *Ventilation*										
IAQ Plan	√	√		√		√		√	√	√
Natural ventilation	√	√	√	√	√	√		√		√
Ventilation system	√	√	√	√	√	√	√	√	√	√
Air purification	√	√	√	√		√	√	√	√	√
Air quality sensors	√	√	√			√	√	√	√	√
(*e*) *Contamination level*										
VOC level	√	√	√	√	√	√	√	√	√	√
Formaldehyde level	√	√	√	√		√			√	
Waste										
Construction waste management	√	√	√	√		√	√			√
Waste treatment	√	√	√	√	√	√		√	√	√
Waste storage and facilities	√	√	√	√	√	√		√	√	√
Material										
(*a*) *Material selection*										
Low environmental impact	√	√		√		√	√			√
Use of renewable material			√	√	√					
Use of recycled material			√	√					√	√
Reuse of structural frame material		√	√	√						√
Material efficiency over its life cycle	√		√		√				√	√
Building fabric material	√			√		√				
Regional material				√						√
(*b*) *Material disclosure information*										
Responsible source of materials	√	√	√	√		√	√	√	√	√
Material ingredient		√	√				√			
(*c*) *Efficient Use of Material*										
Modular and standardised design				√						
Prefabrication			√	√					√	√
(*d*) *Use of green products*			√	√				√	√	√
Energy										
(*a*) *Energy performance*										
HVAC System	√	√	√	√	√	√		√		√
Refrigerator	√	√								√
Lift/escalator	√		√			√		√		

External lighting	√		√		√	√		√		
Car park				√				√		√
Roof								√		√
Building envelope			√	√	√	√		√	√	√
(*b*) *Efficient operation*										
Optimum performance and energy saving	√	√	√	√		√	√	√	√	√
CO_2 mitigation strategy	√	√		√		√				√
Energy efficient fittings	√			√		√		√		
(*c*) *Energy management*										
Energy metering and monitoring	√	√	√	√		√	√		√	√
(*d*) *Natural resources*										
Renewable energy technology	√	√	√	√	√	√		√	√	√
Pollution										
Refrigerant impact	√	√	√	√		√	√	√		
Night light pollution	√	√	√	√	√	√	√			√
Noise pollution	√		√	√		√				
Watercourse pollution	√			√	√	√	√			√
Heat island effect		√	√	√		√	√	√	√	√
NO_x emissions	√		√	√		√				
CO_2 emissions			√	√		√				√
Construction activity pollution		√		√	√	√				√
Wind pollution			√							
Innovation										
Exemplary performance	√	√		√						√
Innovation in design	√	√		√			√	√	√	√
Accredited professional	√	√		√			√	√	√	√
Economic										
Construction cost										
Life cycle cost	√									√
Operating and maintenance cost										
Investment risk										
Affordability of residential rental										
Impact of project on land value of adjacent properties										
Impact of project on local economy										
Commercial viability										
Social										
Regional priority		√								
Handicapped accessibility				√						√
Public open space			√							
Building amenities			√	√						
Cultural										
Design compatible with cultural values			√							√
Improve streetscapes			√							
Use of traditional local materials and techniques			√							
Maintain heritage value		√	√	√						√
Quality of service										
Safety and security	√			√						
Functional and efficiency			√							
Flexibility and adaptability	√		√	√		√	√			
Maintenance of performance			√			√			√	√
Durability and reliability	√		√							

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